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PHYTOPATHOLOGY

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THE PHYSIOLOGY OF PERITHECIAL AND PYCNIDIAL FORMATION IN VALSA LEUCOSTOMA

LEON H. LEONIAN[1]

Although considerable work has been done on the physiology of reproduction in fungi, especially the Phycomycetes, we still know comparatively little concerning the physiology of sexual reproduction in the Ascomycetes. This is due, perhaps, to the fact that most of the Ascomycetes fail to form their perfect stages in artificial cultures, and that they do not lend themselves as readily as the Phycomycetes to the ordinary technique of physiological experiments in the laboratory.

Klebs (3) in his work with *Eurotium repens* concluded that the quality and the quantity of food exerted no special influence upon the conidia and ascospore formation in this fungus. In case of *Saprolegnia mixta*, however, he (4) found food modifications to be the chief controlling factors in reproduction. Others verified Klebs' findings and extended them to different species. Klebs (5) advanced the theory that ascospore formation in yeasts was determined exclusively by the lack of food at a certain period in the life cycle of these plants. Guillermond (2) summarizing the works of Klebs, Hansen, Saito, etc., concluded that a great number of other factors enter into the physiology of ascospore formation in the yeasts. Raciborski (7) found that high food concentrations hindered zygospore formation in Basidiobolus, but Falck (1), on the other hand, reports that high concentrations of a normal nutrient medium induced zygospores in *Sporodinia grandis*. Shear and Wood (8) after reviewing the physiological investigations of other workers concluded that "no cases have been reported in which the evidence was sufficiently conclusive to prove that perithecia were produced in artificial cultures as the direct result of modifications of culture media," and that "the productions of perithecia is a hereditary racial character which does not depend primarily on special conditions of nutriment and

[1] Read at the Boston meeting of the Mycology Section of the Botanical Society of America, December, 1922.

Scientific Paper No. 3, West Virginia Agricultural Experiment Station.

environment." However, we have the work of Smith (9) showing that alkaline media prevented perithecia formation in *Nectriella tracheiphila*. In a former paper the writer (6) reported that perithecial formation in *Valsa leucostoma* was controlled largely by certain chemical factors. Since then the fungus has been studied more extensively, and it has been possible to control its ascigerous and pycnidial reproduction at will.

This fungus seems to possess two strains: in one of these strains the mycelium, the conidia, or the ascospores are capable of giving rise to the perfect as well as to the imperfect stages; in the other one, no matter what the environmental conditions may be, no perithecia develop. However, no morphological differences have been found between the conidial phases of these two strains. Nor could any difference be seen between the physiological efficiency, the nature of infection, and the subsequent pathological symptoms produced by them. The writer feels justified, therefore, in considering the two strains to be identical, with the exception that the ascigerous stage has been lost from the life cycle of one of these, and that probably it can not be introduced again by mere physiological changes. It is also probable that this organism possesses a heterothallic as well as a homothallic strain. While a few organisms of this type have been described, we cannot feel justified in assuming that heterothallism may be widely prevalent in the Ascomycetes, and that it offers the only explanation for the absence of the perfect stage from the life cycle of the Imperfecti. Heterothallism is a fascinating enough subject to become a scientific fad if handled without caution, and it may overshadow the more fundamental facts.

The strain used in following experiments was obtained from an ascospore. The mycelium, conidia, or ascospores of this culture, if grown in a favorable nutrient medium, are capable of producing both the imperfect and the perfect stages. Therefore, all variations pertaining to the control of reproduction, as recorded in this paper, are to be ascribed to environmental modifications rather than to the inherent potentialities of the fungus alone.

THE EXPERIMENTS

Methods. A new technique and a new nutrient solution, which were developed in connection with some other work, have been used throughout these experiments. Filter paper, and small, circular glass capsules of 20 c. c. capacity have replaced agar-agar and test tubes respectively. Filter paper sheets were cut into equal pieces; each piece was moistened with sterile, distilled water, folded and pressed into a circular disc, dried,

placed in the capsule and sterilized in the autoclave. A small quantity (3 to 4 c. c.) of a nutrient solution was then added. The filter paper pads remain constantly moist and afford a good substratum for the growth of the fungus which eventually covers the paper with a mycelial mat and its fruiting bodies. At least thirty different organisms have been grown by the writer on filter paper pads thus prepared, and all have given excellent results. This method enables the investigator to wash his cultures free from one solution, and to transfer them to any desired solution without disturbing the mycelium. The standard solution used in this work consisted of the following ingredients: KH_2PO_4 1.2 grams, $MgSO_4$ 0.6 gram, peptone 0.6 gram, maltose 6.25 grams, malt extract 6.25 grams, distilled water 1000 cc.

The effect of the quantity of food. Three concentrations of the standard solution have been used; no. 1 is the most dilute ,containing only 0.37 per cent of food; no. 2 is the standard concentration with 1.5 per cent of food in solution, while no. 3 represents the solution of the highest concentration with a total of 24 per cent of food matter. The following experiments were set up:

1. The fungus was grown on filter paper pads kept saturated with solution no. 1.

2. The fungus was grown on filter paper pads kept saturated with solution no. 2.

3. The fungus was grown on filter paper pads kept saturated with solution no. 3.

4. The fungus was grown on filter paper pads partially submerged in solution no. 2. After the perithecia attained their fullest development, the culture was removed from the dish and a sterile filter paper pad was placed in the old solution and inoculated with the fungus to see if the solution retained enough food to induce another crop of fruit bodies, and whether any of the specific factors affecting either pycnidia or perithecia development were entirely used up by the first crop of fruit bodies.

5. After a good hyphal growth was made in solution 2 and before any fruit bodies appeared, the culture was transferred, at intervals of three days, to a fresh supply of solution no. 2 until the end of the experiment (16 weeks).

Table 1 gives the results: Roman numeral I means very poor, V most abundant, while the other numerals are intermediates between the two.

TABLE 1—*The effect of food concentration upon growth of Valsa leucostoma.*

Experiments	Quantity of mycelium	Quantity of pycnidia	Quantity of perithecia
1. Fungi grown in solution no. 1	I	I	I
2. Fungi grown in solution no. 2	II	II	III
3. Fungi grown in solution no. 3	V	V	V
4. Fungi were grown in solution which had previously matured a full crop of perithecia	I	I	I
5. The cultures were transferred to a fresh supply of the standard solution at intervals of three days.	V	IV	IV

It can be seen that the quantity of mycelium, pycnidia, and perithecia increased in direct proportion with the increase of food concentration; however, the time required for fruiting was found to be proportionately longer in the richer solutions. This is as it should be; a large amount of mycelium formation is a time consuming process, so that a more luxuriant vegetative growth requires a correspondingly longer period for its full development.

It may be assumed that reproduction, as shown by Klebs and others in case of many Phycomycetes and some of the Ascomycetes, is governed by a gradual, or a rapid food reduction, or a total absence of food. If this be the case, then we will be obliged to suppose that when grown in a nutrient soluton which contained twenty-four per cent of food, the fungus exhausted all or most of the available nutirent matter before it was able to form perithecia. But this is not the case as we can see from experiment 4. Here a very dilute nutrient solution, after maturing a full crop of perithecia, contained enough food to induce a new mycelial growth and the production of another crop of pycnidia and perithecia. If absence of food, as such, constituted the chief factor in perithecia formation, then we would fail to find this second crop of perithecia. It seems that ordinarily the life cycle of the fungus goes through a mycelium-pycnidia perithecia rotation regardless of the quantity of food, provided that the quality is favorable. A lack of food may hasten reproduction in an otherwise normally nourished mycelium, but it neither induces nor controls it. The mycelium requires certain physiological changes preparatory to reproduction; if food conditions which affect these changes can be controlled, then the regular rotation may be broken up and either the perfect or the imperfect phase of the fungus be induced and perpetuated.

In experiment 5, where the cultures were repeatedly transferred to a fresh supply of nutrient solution, the mycelium, the pycnidia and the

perithecia attained a great increase in their development. A constant presence of food of approximately constant concentration causes a longer period of vegetative growth, delays reproduction, but induces a much more luxuriant fruiting.

Perithecia may be induced not only by a sudden or gradual decrease of food, but also, and much more readily and abundantly, by a sudden increase in the food concentration, as shown in table 2.

The effect of increased or decreased food concentration. Working with twenty different representatives of the Sphaeropsidales,[1] the writer showed that food reduction not only is not a controlling factor in pycnidia formation in most of these organisms, but it even checks reproduction, and that nutrient solutions of high food concentrations are conducive to better vegetative growth and pycnidia formation. The same holds true in case of *Valsa leucostoma* as can be seen in the following table:

TABLE 2—*Effect of increased and decreased food concentration upon Valsa leucostoma.*

Experiments	Quantity of pycnidia	Quantity of perithecia
1. Check; grown in standard solution.	II	III
2. Check; grown in the high concentration of the standard solution.	V	V
3. Cultures were grown in the standard solution; after they made a good vegetative growth, they were washed in sterile distilled water, and transferred to sterile distilled water.	II	III
4.* Cultures were grown in the standard nutrient solution, and after they had made a good vegetative growth, they were washed and transferred to the standard solution of high concentration.	V	I
5. Cultures were grown in the nutrient solution of high concentration, and after they had made a good vegetative growth, they were washed and transferred to sterile distilled water.	II	II
6. Cultures were grown in the nutrient solution of high concentration, and after they had made a good vegetative growth, they were washed and transferred to the solution of standard concentration.	II	V

[1] Paper to appear in American Journal of Botany.

* While perithecia were only very few on the old mycelium, they formed in great numbers on the hyphae which grew out from the edges of the old culture into the solution after the cultures were transferred from the low to the high concentration; no pycnidia appeared on this new growth.

It is evident that while a transfer from low concentration of food to distilled water failed to affect reproduction, a transfer from high concentration to distilled water reduced the quantity of both pycnidia and perithecia. A sudden change of osmotic pressure cannot be considered as a factor, because when the process was reversed, e. g. when the cultures were transferred from low to high concentration the pycnidia formation reached the maximum. Perhaps a gradual leaching of material from the protoplasm into distilled water was responsible for this decrease in reproduction. A transfer from a solution of high food concentration to a greatly dilute solution induced a maximum reproduction of perithecia and suppressed the development of pycnidia; the opposite being the case when the process was reversed. This indicates that the requirements for pycnidia and perithecia formation are not similar and that they depend upon certain physiological changes which do not occur simultaneously but at different times in the growth and age of the mycelium. Why should perithecia formation be preceded by pycindial development in the normal life cycle of this fungus? Is it because of the decrease of food concentration to a certain minimum as claimed by other investigators in case of some Phycomycetes and as seemingly supported by the experiments 4 and 6 of the foregoing table? In these experiments a sudden increase of food stimulated pycnidia and checked the quantity of perithecia, the opposite being true when the process was reversed. But we have seen that (Table 1, experiments 1 and 4) even in the most dilute solutions the fungus goes through its regular rotation of mycelium-pycnidia-perithecia, and that no apparent suppression of vegetative or reproductive parts occurs. The changes within the mycelium are independent of those in food concentration, and if these physiological changes are timed and subjected to the changes in food concentration, a proper control of the perfect or imperfect phases can be brought about (Table 2, experiments 4 and 6). Why in experiment 4 of table 2, should the old mycelium give rise to only a few perithecia and produce a large quantity of pycnidia, and why should the new mycelium give rise to perithecia and not pycnidia? It seems that physiological changes within the protoplasm are responsible for this. The experiments given in the following pages furnish further proof for the support of this hypothesis.

Control of perithecial and pycnidial formation. Three nutrient solutions have been used in these experiments. Solution A is the standard medium already described; solution B, consists of the standard solution minus malt extract; and solution C, consists of 1 gram of ammonium nitrate,

0.5 gram of dihydrogen potassium phosphate, 0.25 gram of magnesium sulphate, 5 grams of cane sugar, and 100 c. c. of distilled water. When grown in either one of the last two solutions *Valsa leucostoma* fails to produce pycnidia or perithecia, although a fair amount of vegetative growth is made. This fact led to the theory that if a solution unfavorable to reproduction was introduced into the life cycle of this organism, either temporarily or permanently, pycnidia and perithecia development would exhibit interesting modifications. Consequently experiments were set up as shown in table 3.

It can readily be seen that solution C hinders reproduction when it is used by itself or even when it is supplied to the fungus after the cultures have made a good mycelial growth in solution A and then transferred to solution C. However, when the fungus is first grown in solution C and then transferred to solution A, not only no suppression of fruit bodies occurs, but pycnidia are noticeably increased in number. Apparently the unfavorable factor, (ammonium nitrate), which was carried over in the mycelium, was either gradually assimilated, or else it was neutralized by the effect of the more favorable nutrient solution. The increased pycnidial reproduction is to be attributed largely to the fact that the fungus was able to absorb more food from the two different solutions which were introduced into its life cycle, and was also affected by the greater variety of food constituents which were furnished to it. The most remarkable phenomenon, however, is to be observed in the manner of perithecia development; instead of appearing on the mycelium and separate from the pycnidial stromata, as is their natural habit, the perithecia formed on the top of pycnidial stromata, appearing as small, rostrate bodies studded on pycnidial heads.

In the last four experiments of table 3 where the cultures were transferred from solution A to solution C, and then back to solution A again, a marked stimulation of pycnidial reproduction and a total absence of perithecial development is to be noted. It appears that a well developed mycelium, after being transferred to solution C, absorbed too much of the inhibiting factor for perithecia formation, but not enough for the suppression of pyncidia. Perhaps the transfer came at a period in the life of the mycelium when its physiological condition favored pycnidial reproduction rather than perithecial. It should not be assumed that in the last four experiments of the foregoing table the behavior of the mycelium can suggest a possible loss of the power of perithecia formation. A second transfer to a fresh supply of solution A was able to establish the balance so that in due time perithecia appeared, except that they

TABLE 3—*The effect of different solutions upon reproduction of Valsa leucostoma.*

*Experiments	Quantity of pycnidia	Quantity of perithecia	Remarks
1. Check; grown in solution A.	II	III	
2. Check; grown in solution C.	0	0	Only sterile hyphae.
Series x; first grown in solution C and then transferred to solution A.			
3. Transferred to solution A after 2½ days.	II	III	Pycnidia first to appear; later perithecia formed *mostly* on top of pycnidial stromata.
4. Transferred to solution A after 5 days.	II	III	Same as the preceding.
5. Transferred to solution A after 10 days.	III	III	Perithecia formed *only* on top of pycnidial stromata.
6. Transferred to solution A after 15 days.	III	III	Same as the preceding.
Series y; first grown in solution A and then transferred to solution C.			
7. Transferred to solution C after 2½ days	0	0	Sterile mycelium only.
8. Transferred to solution C after 5 days	0	0	" " "
9. Transferred to solution C after 10 days	0	0	" " "
10. Transferred to solution C after 15 days	0	0	" " "
Series z: first grown in solution A till a good hyphal growth was obtained, then transferred to solution C, and 2½, 5, 10, and 15 days later transferred to solution A.			
11. Transferred 2½ days later.	III	0	In series z when the cultures were again washed in sterile distilled water, and were transferred to a fresh supply of solution A, perithecia appeared in due time.
12. Transferred 5 days later.	IV	0	
13. Transferred 10 days later.	IV	0	
14. Transferred 15 days later.	IV	0	

* Before each transfer the cultures were thoroughly washed in sterile distilled water.

altered their usual habit and formed directly on the top of pycnidial stromata. The hyphae of the old mycelium and the hyphae of the stromata have different ages and different physiological potentialities, and it is only natural for them to exhibit different reactions towards the environmental factors. This changed location of fruiting bodies is further shown in table 4.

TABLE 4—*Changed location of perithecia and pycnidia of Valsa leucostoma due to changed food factors.*

Experiments	Quantity of pycnidia	Quantity of perithecia	Remarks
1. The fungus was grown in solution A; after the perithecia were fully developed the cultures were washed and transferred to a fresh supply of solution A.	0	III	Perithecia gave rise to tufts of hyphae at their tips. These tufts developed into stromata, and without giving rise to pycnidia, produced perithecia directly.
2. The fungus was grown in solution A; after the perithecia were fully developed the cultures were washed and transferred to solution C; seven days later they were again washed in distilled sterile water and were transferred to a fresh supply of solution A.	III	III	Perithecia gave rise to pycnidial stromata, and these eventually produced perithecia, thus forming two layers of perithecia separated by a layer of pycnidia.

In the first experiment pycnidia were eliminated entirely because physiological changes which occurred in the mycelium and gave rise to the perfect stage persisted when the entire culture was transferred intact and was disturbed but very little. When the mycelium is cut to pieces, the physiological balance is disturbed and it becomes necessary for the fungus to go through the mycelium-pycnidia-perithecia rotation again. Similarly, if we examine experiment 4 in table 2, we shall find further support for this theory. In that case when the cultures were transferred from the low food concentration to the high food concentration, the old mycelium, in which physiological changes favored only pycnidial reproduction, yielded a scanty crop of perithecia, while the hyphae which formed after the transfer, developed a large quantity of perithecia and no pycnidia.

Experiment 2 of table 4 shows that the location and the relationship of the perfect and the imperfect fruiting bodies to each other can be changed at will by the rotation and the nature of the nutrient solutions.

The effect of the different food constituents. The influence of dihydrogen potassium phosphate, magnesium sulphate, peptone, and maltose, singly and in all possible combinations, was tested. Malt extract was reserved for a separate experiment.

The fungus was grown in the standard solution; when a good mycelial growth was obtained, and before any fruiting bodies formed, the cultures were washed and transferred to the solutions listed in the following table. The amounts of the ingredients used in these solutions are the same as given in the formula of the standard solution.

TABLE 5—*The effect of different food constituents upon Valsa leucostoma.*

Experiment no.	Quantity of pycnidia	Quantity of perithecia	Remarks
1. Transferred to distilled water	II	III	
2. Transferred to a fresh solution of the standard medium	III	IV	
3. Transferred to KH_2PO_4, $MgSO_4$, peptone, maltose	II	IV	
4. Transferred to $MgSO_4$, maltose, peptone	III	III	
5. Transferred to KH_2PO_4, maltose, peptone	III	III	
6. Transferred to $MgSO_4$, KH_2PO_4, peptone	III	III	
7. Transferred to KH_2PO_4, peptone	III	III	Perithecia formed on top of pycnidial stromata only.
8. Transferred to KH_2PO_4, $MgSO_4$	II	III	
9. Transferred to $MgSO_4$ peptone	III	III	Perithecia formed on top of pycnidial stromata only.
10. Transferred to maltose, peptone	III	IV	
11. Transferred to maltose, $MgSO_4$	III III	III III	Perithecia formed on top of pycnidial stromata only.
12. Transferred to KH_2PO_4	II	II	Perithecia formed on top of pycnidial stromata only.
13. Transferred to $MgSO_4$	II	III	
14. Transferred to peptone	II	II	Perithecia formed on top of pycnidial stromata only.

Table 5 shows that all of the food constituents of the standard nutrient solution are able to induce both the perfect and the imperfect fruiting bodies when used either by themselves or in all possible combinations. Some seem to be a little more favorable than others. Dihydrogen

potassium phosphate or peptone, when used singly, proved to be the least favorable but when combined, they induced a better reproduction.

The effect of sugars. Four sugars in different concentrations have been used in these experiments. Of these sugars, maltose, glucose and levulose were pure, while cane sugar was the commercial granulated product. The fungus was grown in the standard nutrient solution; after it made a good hyphal growth and before any of the fruiting bodies appeared, the cultures were washed in distilled sterile water and were transferred to the various sugar solutions listed in table 6.

TABLE 6—*The effect of nitrates upon Valsa leucostoma.*

Experiment No.	Quantity of pycnidia	Quantity of perithecia
1. M/8 maltose	I	0
2. M/16 "	II	0
3. M/32 "	II	1
4. M/64 "	II	III
5. M/8 cane sugar	0	0
6. M/16 " "	I	0
7. M/32 " "	II	0
8. M/64 " "	II	III
9. M/8 Glucose	I	0
10. M/16 "	II	III
11. M/32 "	II	III
12. M/64 "	II	III
13. M/8 levulose	I	0
14. M/16 "	I	III
15. M/32 "	I	IV
16. M/64 "	I	IV

Higher concentrations of sugars tend to reduce pycnidia formation and hinder perithecia development. M/8 concentration of cane sugar solution prevented reproduction altogether. However, it can be seen that the range of pycnidial formation is much wider than that for perithecia, and in this respect *Valsa leucostoma* behaves like most of the other fungi which have been worked with by other investigators. Levulose seems to be the best sugar for inducing the perfect stage, and is the least favorable for pycnidial development.

The effect of nitrates. After the fungus made a good hyphal growth in the standard solution, and before the first fruit bodies appeared, the cultures were washed and transferred to the different solutions of nitrates as listed in following table.

TABLE 7—*The effect of sugars upon Valsa leucostoma.*

Experiment no.		Quantity of pycnidia	Quantity of perithecia
1.	M/8 ammonium nitrate	0	0
2.	M/16 " "	0	0
3.	M/32 " "	0	0
4.	M/64 " "	I	0
5.	M/8 calcium nitrate	III	0
6.	M/16 " "	II	0
7.	M/32 " "	II	0
8.	M/64 " "	II	0
9.	M/8 sodium nitrate	0	0
10.	M/16 " "	II	0
11.	M/32 " "	II	0
12.	M/64 " "	II	0
13.	M/8 potassium nitrate	III	0
14.	M/16 " "	III	0
15.	M/32 " "	II	0
16.	M/64 " "	II	0

Nitrates, as we can see, hinder perithecial development altogether. Ammonium nitrate is uniformly unfavorable for reproduction, and in only the most dilute solution was it able to induce just two or three single pycnidia without stroma. Calcium nitrate and potassium nitrate seem to be more favorable to pycnidia formation in higher concentrations than sodium nitrate.

The minimum absorption of malt extract necessary for reproduction. It was found that the fungus would not reproduce in the ordinary nutrient solution if malt extract was left out from this medium. The solution with malt extract (the standard) has been termed solution A; the one without malt extract is termed solution B for convenience. It was proposed to find out if a mycelium grown in solution B, then transferred to 0.625 per cent of malt extract solution for various lengths of time, and finally transferred back to a fresh supply of solution B would absorb a sufficient quantity of malt extract to induce pycnidia and perithecia. A number of cultures were made in solution B; after a good hyphal growth was obtained the cultures were washed and transferred to malt extract solution for one, five, ten, fifteen, thirty minutes, for one, two, four, eight, twelve, twenty-four, forty-eight, and seventy-two hours, then washed in four changes of distilled sterile water and transferred to a fresh supply of solution B. Table 8 gives the results.

Ten minutes in malt extract solution appears to be the approximately minimum length of time for pycnidial reproduction, and fifteen minutes

TABLE 8—*The minimum absorption of malt extract necessary for reproduction of Valsa leucostoma.*

Experiments	Quantity of pycnidia	Quantity of perithecia
1. Check; cultures were washed and transferred to a fresh supply of solution B without transferring to malt extract solution	0	0
2. Check; cultures transferred to malt extract solution and left there	II	III
3. Cultures were kept in malt extract solution 1 minute	0	0
4. Kept in malt extract 5 minutes	0	0
5. Kept in malt extract 10 minutes	I	0
6. Kept in malt extract 15 minutes	I	I
7. Kept in malt extract 30 minutes	I	I
8. Kept in malt extract 1 hour	I	I
9. Kept in malt extract 2 hours	II	II
10. Kept in malt extract 4 hours	II	II
11. Kept in malt extract 8 hours	II	II
12. Kept in malt extract 12 hours	II	II
13. Kept in malt extract 24 hours	II	II
14. Kept in malt extract 48 hours	II	II
15. Kept in malt extract 72 hours	II	III

for the perithecial development. Longer periods induce better reproduction, but it seems that after a certain period, (72 hours), malt extract does no longer exert any stimulative influence upon reproduction, as a comparison of check no. 2 and experiment 15 will show. It should be remembered in this connection that a mycelium well nourished in the standard nutrient solution reproduces just as well whether it is kept in the same solution or whether it is washed and transferred to distilled water. It seems that after a certain period of growth in a dilute nutrient solution the mycelium no longer depends on the outside food for the formation of its fruit bodies, but utilizes the food and the energy stored within its own protoplasm. There is a balance between the fungus and its food; at a certain stage a withdrawal of food tends to weaken the mycelium, while at other stages it exerts no appreciable influence. This is not because of a total absence of food in the old nutrient solution, or because of a possible presence of some toxic substance given off by the growing fungus, for we have seen that the nutrient solution, after giving rise to one crop of fruit bodies, was able to develop a second crop. Nor can we say that the mycelium, after reaching a certain stage of growth, is unable to absorb and utilize the food in the nutrient solution, for we have seen that when the cultures, after the formation of fruit bodies, were transferred to a fresh supply of the nutrient solution, were

able to absorb food, grow, and give rise to new fruit bodies. In case of higher concentrations of food, however, a constant presence of the nutrient solution seems to be essential. We have seen that cultures after making a good growth in a higher concentration of nutrient solution failed to do well when transferred to distilled sterile water, while a maximum reproduction was the result when they were transferred to a very dilute medium. A sudden increase of food during any part in the growing life of the fungus is conducive to an infinitely better reproduction, and its sudden withdrawal marks a sharp reduction in the quantity of fruit bodies. We can make no definite rules and mould the properties of the living protoplasm into standard forms, because an organism exhibits different reactions with each change occurring either within or without its protoplasm, and these changes are not, ordinarily, perceptible enough to be interpreted according to any set standards.

SUMMARY

1. The strain of fungus used in these experiments produces pycnidia and perithecia if grown in a favorable nutrient medium. Conidia or ascospores show identical physiological reactions to the various solutions used.

2. The quantity of mycelium, pycnidia, and perithecia increased in direct proportion to the increase of food concentration.

3. The same solution, after maturing a full crop of fruit bodies, had a sufficient amount of food left to develop a second crop.

4. When the food supply of the fungus was renewed every three days for about sixteen weeks, mycelium, pycnidia, and perithecia formed in great abundance, showing that an absence or a decrease of food was not a factor in the reproduction of this organism.

5. When transferred from the standard food solution to distilled water, there was no appreciable difference in the quantity of fruit bodies formed; when, however, the mycelium was transferred from a solution of high concentration to distilled water, there was a sharp decrease in reproduction.

6. When the mycelium of this fungus was transferred from the standard solution to the high concentration of the same solution, pycnidia increased in number while perithecia decreased; when the process was reversed, the results were also reversed.

7. Solution C, where cane sugar furnished the carbohydrates and ammonium nitrate supplied the nitrogen, was unable to induce either pycnidia or perithecia. When, however, the mycelium was grown in

this solution and then transferred to the standard solution, there was a marked increase in reproduction. When the process was reversed, e. g. the mycelium was transferred from the standard solution to solution C., reproduction was suppressed. When the mycelium was grown in the standard nutrient solution, then washed and transferred to solution C, and a few days later transferred back to the standard solution again, pycnidia formed in great abundance, while perithecia were suppressed.

8. When the fungus was grown in the standard solution until the perithecia formed, and then washed and transferred to a fresh supply of the nutrient solution, perithecia gave rise, at their tips, to a new crop of perithecia, but no pycnidia developed.

9. When the fungus was grown in the standard solution until the perithecia formed, and then it was washed and transferred to solution C, and a few days later it was again washed and transferred to a fresh supply of the standard solution, perithecia gave rise, at their tips, to stromata with mature pycnidia; eventually these pycnidial stromata gave rise to perithecia. The perfect fruiting bodies appeared as small, rostrate structures studded on globose stromata.

10. When the fungus was allowed to form a good crop of mycelium and then it was washed and transferred to the different food constituents of the standard solution (these ingredients being used either singly or in all possible combination), no suppression of either type of reproduction took place.

11. When the mycelium of the fungus was developed in the standard solution, and then washed and transferred to M/8, M/16, M/32, and M/64 solutions of maltose, cane sugar, glucose, and levulose, it was found that the high concentrations checked perithecia formation; M/8, and M/16 concentrations of maltose, M/8, M/16, M/32 concentrations of cane sugar, and M/8 concentration of glucose and levulose hindered perithecia formation, while only the M/8 concentration of cane sugar prevented pycnidial formation. Levulose was found to be the most favorable for perithecia development and the least favorable for pycnidia production.

12. When the mycelium of the fungus was developed in the standard solution, and then washed and transferred to M/8, M/16, M/32, and M/64 concentrations of ammonium nitrate, calcium nitrate, sodium nitrate, and potassium nitrate solutions, perithecia formation was hindered altogether. M/8, M/16, and M/32 concentrations of ammonium nitrate, and M/8 concentration of sodium nitrate prevented pycnidia formation as well.

13. Solution B, which contains no malt extract but otherwise is just like the standard solution, failed to induce reproduction. When the fungus was grown in this solution until a good mycelial growth was obtained, then washed and transferred to 0.6 per cent of malt extract for one, five, ten, fifteen, and thirty minutes, and one, two, four, eight, twelve, twenty-four, forty-eight, and seventy-two hours, and then washed and transferred to a fresh supply of solution B, it was found that one and five minutes' exposure to malt extract solution induced no reproduction whatsoever; ten minutes' exposure induced pycnidia, and fifteen minutes' exposure induced both pycnidia and perithecia. Longer exposures merely served to increase the number of fruit bodies.

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LITERATURE CITED

(1) FALCK, RICHARD. Die Bedingungen und die Bedeutung der Zygotenbildung bei Sporodinia grandis. Cohn. Beitr. Biol. Pflanzen **8**: 213–306. *Pl. IX–XI.* 1901.

(2) GUILLIERMOND, ALEXANDRE. The yeasts. Tr. by F. W. Tanner. *xix, 424 p., illus.* 1920. Bibliographical index, p. 381–409.

(3) KLEBS, GEORG. Die Bedingungen der Fortpflanzung bei einigen Algen und Pilzen. *xviii, 543 p., 15 fig., 3 pl.* Jena. 1896. Litteratur-Verzeichnis. p. 536–543.

(4) ———————. Zur Physiologie der Fortpflanzung einiger Pilze. II. Jahrb. Wiss. Bot. **33**: 513–593. 1899.

(5) ———————. Zur Physiologie der Fortpflanzung einiger Pilze. III. Jahrb. Wiss. Bot. **35**: 80–203. 1900. Litteratur-Verzeichniss, p. 199–203.

(6) LEONIAN, L. H. Studies on the Valsa apple canker in New Mexico. Phytopath. **11**: 236–243. 1921. Literature cited, p. 243.

(7) RACIBORSKI, M. Ueber den Einfluss äusserer Bedingungen auf die Wachsthumsweise des Basidiobolus ranarum. Flora **82**: 107–168. *11 fig. 1896.*

(8) SHEAR, C. L. AND A. K. WOOD. Studies of fungous parasites belonging to the genus Glomerella. United States Dept. Agric. Bur. Plant Ind. Bull. 252. *110 p., 2 fig., 18 pl.* 1913. Literature cited, p. 101–105.

(9) SMITH, E. F. Wilt disease of cotton, watermelon, and cowpea. United States Dept. Agric. Div. Veg. Phys. and Path. Bull. 17. *72 p., 10 pl.* 1899.

ON THE RELATION OF TEMPERATURE TO THE DAMPING-OFF OF GARDEN-CRESS SEEDLINGS BY PYTHIUM DEBARYANUM AND CORTICIUM VAGUM

TAKEWO HEMMI

WITH TWO FIGURES IN THE TEXT.

INTRODUCTION

The economic importance of damping-off diseases in the United States was first emphasized by Atkinson (1), who stated that treatment of these diseases requires special attention to the environmental conditions that influence the development of the pathogenic organisms. He concluded that damping-off is favored by high temperature, wet soil, humid atmosphere, weak light and lack of ventilation. Rhizoctonia (the sterile stage of *Corticium vagum* B. et C. var. *solani* Burt) causes not only damping-off of seedlings, but also cankering of potato stems. Rolfs (17, 18) concluded that high temperature and abundant moisture were accompanied by rapid development of this organism on potato in Colorado. Balls (2) observed that high soil temperature apparently prevented the injury of cotton by Rhizoctonia, while lower soil temperatures favored the pathogenic action of this fungus. The same writer (3) found experimentally that Rhizoctonia mycelium infected cotton seedlings at 20° C., but not at 33° C. Morse and Shapovolov (14) observed great injury of field potato plants by Rhizoctonia in the hottest part of the summer, and Peltier (15), who studied various strains of this fungus experimentally, expresses the opinion that high temperature, together with too little or too much moisture, favors injurious infection. Johnson (6) showed that excessively moist and hot weather favors the occurrence of damping-off diseases. He considered the optimum temperature for the growth of Rhizoctonia to be about 25° C., while that of Pythium was thought to be about 33° C., and he pointed out the need for a knowledge of the relation of temperature to the occurrence of these diseases.

Gilman (5) and Tisdale (19, 20) studied first the relation of soil temperature to Fusarium infections. Jones (10) emphasized the desirability for studying environmental relations in plant pathology, dwelling especially on the great need for studies of soil temperature as related to the pathogenicity of the organisms that cause plant diseases. Johnson

and Hartman (8) studied the relation of soil conditions to rootrot of tobacco, reaching the conclusion that soil temperature is undoubtedly the most important of these conditions. Clayton (4) and several other authors reported experimental results from studies on several diseases, and Jones (11) has recently summarized the progress thus far made in this important field. Johnson (7) further gave specia' attention to air temperature as an influential condition.

Although practical experience seems to teach that damping-off by Pythium is more serious with high temperatures and that caused by Rhizoctonia is more serious with lower temperatures, this relation has not been thoroughly studied experimentally. One report of experimentation of the sort just indicated has been published by Richards (16), on the pathogenicity of Rhizoctonia to potato stems, as related to soil temperature. Pure cultures or sclerotia of the fungus produced lesions near the base of the stem with temperatures of 9° to 27° C., the greatest damage occurring between 15° and 21° C. The fungus was pathogenically most active at 18° C. Richards concluded that it is only with temperatures below 24° C. that this fungus is a serious hindrance to potato production.

The present paper reports the results of an experimental study of the relation of soil temperature and air temperature to the pathogenicity of *Pythium DeBaryanum* Hesse and of *Corticium vagum* B. et C. var. *solani* Burt towards seeds and seedlings of garden cress (*Lepidium sativum* L.) in greenhouse cultures. The experiments were done in the Department of Plant Pathology of the University of Wisconsin, during the spring of 1922. The writer wishes to express his indebtedness to Doctors James Johnson, A. G. Johnson and F. R. Jones, for suggesting this study, and his special gratitude to Doctors James Johnson and Jones, for kindly supplying cultured strains of the fungi and for much other help. The writer is also greatly indebted to Doctors L. R. Jones, G. W. Keitt, E. M. Gilbert, and others, for helpful suggestions. Finally, he wishes to express his hearty thanks to Doctor Burton E. Livingston, of the Laboratory of Plant Physiology of the Johns Hopkins University, who read the original draft of the manuscript and did much editorial work on it, especially with regard to its condensation into as brief a form as possible.

THE ORGANISMS USED

From seven strains of Pythium and an equal number of Rhizoctonia, a single strain of each was selected by means of preliminary tests on pathogenicity toward seedlings of garden cress and of lettuce. The

Pythium strain selected had been isolated from sugar beet by Dr. F. R. Jones, and the Rhizoctonia strain had been secured from a soil in Connecticut by Dr. James Johnson. Pure cultures of each of these were prepared and were used as sources for inoculation in the experiments to be considered below, the Pythium being grown on corn-meal agar and the Rhizoctonia on potato agar. Besides exhibiting pathogenicity toward garden cress, both of these strains produced disease in tomato and cucumber seedlings. Lettuce seedlings were seriously injured by this Rhizoctonia strain, but apparently not by this Pythium strain.

EXPERIMENTATION WITH SOIL TEMPERATURE ALONE APPROXIMATELY MAINTAINED

In the first series of experiments only the soil temperature was controlled. The culture vessels were galvanized sheet-iron cylinders, 15 cm. in diameter and 25 cm. deep, standing in water baths with suitably controlled temperatures. The apparatus used has been described by Jones (10) and by Johnson and Hartman (8). The cylinders were nearly filled with soil, and the soil surface was affected by the air temperature of the greenhouse. Consequently the surface soil varied in temperature somewhat, tending to follow the fluctuating air temperature. Attempts to reduce the temperature variation in the superficial soil layers, by means of paper covers, etc., were not very successful. The upper layers of soil in the different baths were very different, however, in spite of this variation.

A 5-cm. layer of artificially infested soil (made by mixing pure cultures of the fungus with sterilized soil) was added above an 11 cm. layer of sterilized soil in the bottom of each cylinder, and a 2.5 cm. layer of sterilized soil was added above this, on which 100 or 150 cress seeds were placed, covered with another layer of sterilized soil about 1.5 cm. deep. Controls were prepared in the same manner, but with sterilized soil only. Soil temperatures for the superficial layer were determined from time to time, by means of thermometers, and water was added when it seemed to be needed.

After the seedlings had appeared they were frequently examined, to determine the degree of infection for each temperature tested. At the end of each experiment the number of healthy seedlings in each control cylinder and the number in the corresponding infested cylinder were recorded. In many cases the seeds were infected and failed to germinate, or the seedlings were killed before reaching the soil surface, and an in-

direct method of determining the degree of infection was consequently employed. To secure a measure or index of infection, the number of healthy seedlings in the infected cylinder was expressed as a percentage of the corresponding number in the control cylinder at the same temperature, and this value was finally subtracted from one hundred. The temperature ranges secured in the upper soil layers were about as follows, from four to six of the ranges being tested for each fungus in each experiment:

13–17° C.	18–22° C.	23–25° C.	28–30° C.
14–15° C.	18–23° C.	23–27° C.	28–31° C.
14–16° C.	19–21° C.	24–27° C.	28–32° C.
14–17° C.	19–23° C.	25–27° C.	29–30° C.
15–18° C.	21–24° C.	25–28° C.	29–31° C.
16–17° C.	22–24° C.	26–28° C.	29–33° C.
16–18° C.	22–25° C.	26–29° C.	30–32° C.
18–21° C.	22–27° C.	27–30° C.	32–34° C.

After the completion of six experiments, during the carrying out of which a number of difficulties in technique were encountered and wholly or partially overcome, it was found that the consensus of all the results was as follows: With low and with high temperature ranges, and for both the fungi, infection was not as serious as with medium ranges. Neither fungus produced infection with the highest range tested (32–34° C.). In one case Rhizoctonia produced infection with temperature 30–32° C. With temperature 29–33° C. both fungi failed to give infection. With temperatures above 30° it is, however, unlikely that infection by this strain of Rhizoctonia would appear under the general conditions of these experiments, while infection by this strain of Pythium should be expected frequently. With lower temperature ranges there was always more infection by both the fungi. The controls were uniformly without infection. Damping off by Pythium was generally most serious with temperature ranges between 22° and 27°, while that by Rhizoctonia was generally most serious with temperature ranges between 16° and 23°. With the lowest temperature tested both fungi were still dangerous parasites. From counts of the seedlings in each control cylinder it appeared that the highest percentage of germination of the seeds occurred within the temperature range 18–23° C. Germination was markedly retarded with temperatures above 30° C.

These generalizations are not to be considered as precise; they are only rough approximations. Whether or not infection is to occur in any culture is of course determined by a group of conditions, of which the soil temperature and the presence of the active fungus are only two.

Evidence was noted supporting the supposition that air temperature and air humidity are additional influencial conditions in this respect. The writer has also to call attention to the fact that, with both fungi, growth often occurs on the surface of the soil and the seedlings are attached at that level. Another series of experiments will now be considered, for which the soil and the air temperatures were both controlled.

EXPERIMENTATION WITH BOTH SOIL AND AIR TEMPERATURES MAINTAINED AND ALIKE

The experiments to be dealt with now were carried out with the culture vessels (4-inch pots of the ordinary type used in greenhouses) in thermostatically controlled chambers, the temperature of the soil being very nearly the same, in every case, as that of the air above, and both soil and air temperatures were maintained within a rather narrow range. The chambers used have been described by Johnson (7). Aside from the form of culture vessel used, and the temperature and air-humidity control, the procedure was essentially similar to that followed in the experiments considered above. The water-vapor-tension deficit[1] was nearly the same for all temperature ranges. For the entire range of mean temperatures considered (10°–37° C.), the deficit range was from 3.5 mm. to 9.1 mm. of mercury column. Each experiment included, for each temperature range, six cultures, two for each of the two fungus strains and two as controls.

Four successful experiments were carried out. The numerical data for these summarized in table 1. The temperature and relative humidity ranges are given in the first two columns the approximate means of temperature and of relative humidity are given in the next two columns, and the approximate mean saturation deficits are given in the fifth column. The number in parenthesis in the first column denotes the serial number of the experiment in which the given temperature range was tested.

[1] The vapor-tension deficit is a measure of the tendency of the air to take up water vapor, disregarding wind movements, which may be assumed to have been about alike in all chambers. It is derived from the mean temperature and the mean relative humidity in each case, by multiplying the maximum vapor pressure of water for the given temperature by the relative humidity value (considered as hundredths) and then subtracting the product from the maximum vapor-pressure value. Thus, for an mean temperature of 10 C. and a mean relative humidity of 62 per cent., we multiply 9.165 mm. by .62 and obtain 5.682 mm., which we subtract from 9.165 mm., obtaining 3.483 mm., the deficit value sought. The maximum vapor tension is of course to be found from tables of physical constants. In this connection, see (9, 12, 13).

The calculated percentages of infection are given, for each of the two fungi, in the sixth and seventh columns. Percentages of infection that are above 80 are shown in bold-face type in the table. Percentages of germination (number of seedlings produced in the controls, divided by 80 (number of seeds planted), and that quotient multiplied by 100 are shown in the last column.

TABLE 1.—*Numerical data from experiments with soil temperature and air temperature maintained and alike.*

Temperature Range	Relative Humidity Range	Mean Temperature (approx.)	Mean Relative Humidity (approx)	Mean Vapor-tension Deficit (approx)	Percentage of Infection by		Percentage of Seed Germination (controls
					Pythium	*Corticium* (*Rhizoctonia*)	
deg. C.	*per cent*	*deg. C.*	*per cent*	*mm. of Hg*			
8–12 (**2**)	54–70	10	62	3.5	24.1	72.4	72.5
13–18 (**1**)	44–55	16	50	6.7	45.6	**87.7**	71.3
15–18 (**3**)	40–60	17	50	7.2	64.4	**93.2**	73.8
19–21 (**4**)	49–60	20	55	7.8	**92.7**	69.1	68.8
20–23 (**2**)	54–72	22	63	7.3	**83.6**	**85.2**	76.3
22–26 (**3**)	60–80	24	70	6.6	**85.5**	**80.0**	68.8
25–27 (**3**)	68–83	26	76	6.0	**96.2**	67.9	66.3
28–31 (**2**)	75–93	30	84	5.0	**87.5**	68.8	40.0
28–32 (**1**)	68–85	30	77	7.3	**90.0**	53.3	37.5
33–35 (**4**)	65–88	34	77	9.1	0	0	0
35–38 (**1**)	80–90	37	85	7.0	0	0	0

The following paragraphs bring out the more striking points of each experiment.

Experiment I. March 18–31. With temperature range 35–38°, germination was almost inhibited in both infested and control cultures, and germination was best with the lowest range (13–18°). The plantlets are shown to have been much more seriously attacked by Pythium with temperature range 28–32° than with range 13–18°. On the other hand, Rhizoctonia injury was markedly more serious with range 13–18° than with range 28–32°.

Experiment II. April 4–22.—Germination is shown to have been best with temperature range 20–23°, but with range 8–12° the germination percentage is nearly as high. The most serious injury by Pythium occurred with range 28–31°, while Rhizoctonia injury was most serious

with range 20–23°. With range 8–12° one seedling was affected by Rhizoctonia after its shoot emerged from the soil. At the end of the experiment all cultures were removed from the chambers and placed on the greenhouse bench, where the temperature of the surrounding air might be considered as suitable for infection After two days marked infection was shown in all infested cultures, but the controls remained free from disease.

Experiment III. April 25–May 7.—Germination was nearly the same in all the controls. The most serious Pythium injury occurred for temperature range 25–27°, while Rhizoctonia injury was most marked for range 15–18°. Range 22–26° gave intermediate infection percentages for both fungi.

Experiment IV. May 18–28.—For temperature range 33–35°, no germination occurred in control cultures (two seedlings grew in one infested pot), but germination was good for the other range of this experiment (19–21°). Both fungi attacked the plants vigorously with the lower range.

Considering all the data of table 1, it appears that the Pythium strain here dealt with caused disease in more than 80 per cent of the seeds and seedlings for temperature ranges from 19–21° to 28–32°, or from about 20° to about 30°, and all ranges thus included were apparently about alike in this respect With lower temperature ranges the percentage of infection was progressively lower, but the lowest range tested (8–12°) gave 24.1 per cent of injury. For the highest two ranges tested, there was no germination in any control pots (few seedlings came up in some infested pots), and it appears that a temperature high enough to prevent infection by this Pythium would be so high as to inhibit seed germination of this Lepidium.

As to infection by the Rhizoctonia strain here studied, the infection percentages are above 80 per cent for ranges 13–18 °, 15–18°, 20–23°, and 22–26°. Disregarding the exceptional case of range 19–21°, we may say that this fungus was very injurious for temperatures from about 16° to about 24°. The lowest range tested (8–12°) gave an injury value of 72.4 per cent. For ranges above 24° the injury was smaller, but its value is 53.3 per cent, for the highest range with which germination occurred in the controls (28–32°).

These results indicate clearly that the range of temperatures favoring injury to these seedlings is very wide for both fungi but that this Pythium was most injurious for temperatures between 20° and 30°, while this Rhizoctonia was most injurious for a lower range between 16° and 24°. (See figs. 1, 2.)

The relation of temperature to seed germination in these experiments may be studied by means of the data in the last column of the table. Germination seems to have been sensibly about alike (68.8–76.3 per cent) for all temperatures from about 10° to about 24°. With higher temperatures germination was hindered, and for ranges 33–35° and 35–38° it was inhibited.

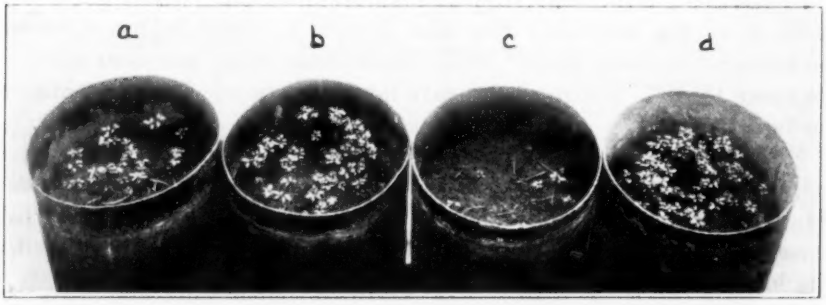

Fig. 1. Seedlings of *Lepidium sativum* L. grown with soil temperature about 26° C. a, in Corticium- (Rhizoctonia) infested soil. c, in Pythium- infested soil. b and d, in uninfested soil.

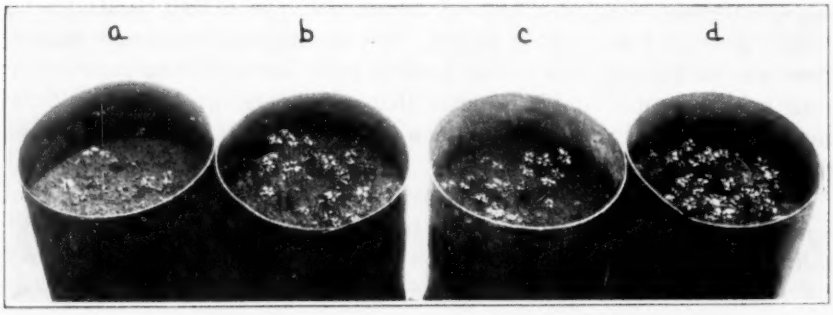

Fig. 2. Seedlings of *Lepidium sativum* L. grown with soil temperature about 16° C. a, in Corticium-(Rhizoctonia) infested soil. c, in Pythium-infested soil. b and d, in uninfested soil.

GENERAL CONCLUSIONS

In a general way, the results of the two series of experiments considered above agree in showing (1) that both fungi were injurious to garden cress seeds and seedlings for temperatures between about 10°

and about 30° C. No statement for higher temperatures can be made, since those tested inhibited seed germination. Lower temperatures were not tested. (2) These results also show that the Pythium strain here used was less injurious to these Lepidium seedlings than was the Rhizoctonia strain for temperatures below about 20° C., and more injurious than the Rhizoctonia strain for temperatures above about 24° C. (3) For temperatures from about 17° C. to about 26° C., both fungi were very injurious. (4) The temperature ranges of most active infection may be stated, approximately, as follows:—

Pythium de Baryanum	20–30°C.
Corticium vagum (Rhizoctonia)	16–24°C.

(5) The Lepidium seeds used germinated well for temperatures from about 10° to 24° C. Lower temperatures were not tested. Germination was markedly retarded or entirely inhibited with temperatures above about 30° C.

These conclusions are of course not to be taken as applicable to other fungi or hosts and they are only approximate, even for the organisms employed in these experiments and for these experimental conditions.

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LITERATURE CITED

(1) ATKINSON, G. F. Damping off. New York Cornell Agric. Exp. Sta. Bull. 94: 233–272. *fig. 55, 6 pl.*. 1895.

(2) BALLS, W. L. The physiology of a simple parasite. Yearbook Khediv. Agric. Soc. **1905:** 171–195. *Pl. VI–VII;* **1906:** 91–111. *Pl. XIII–XVI.* 1906–1907.

(3) ————. Temperature and growth. Ann. Bot. **22:** 557–591. *11 fig.* 1908.

(4) CLAYTON, E. E. The relation of soil temperature to the development of the tomato fusarium wilt. (Abstract.) Phytopath. **10:** 63–64. 1920.

(5) GILMAN, J. C. Cabbage yellows and the relation of temperature to its occurrence. Ann. Missouri Bot. Gard. **3:** 25–84. *21 fig., pl. 1–2.* Literature cited, p. 78–81.

(6) JOHNSON, JAMES. The control of damping-off disease in plant beds. Wisconsin Agric. Exp. Sta. Research Bull. **31:** 29–61. *12 fig.* 1914. Literature cited, p. 60–61.

(7) ————. The relation of air temperature to certain plant diseases. Phytopath. **11:** 446–458. *2 fig., pl. XXI–XXIII.* 1921. Literature cited, p. 457–458.

(8) ———— AND R. E. HARTMAN. Influence of soil environment on the root-rot of tobacco. Jour. Agric. Res. **17:** 41–86. *2 fig., pl. 1–8.* 1919. Literature cited, p. 85–86.

(9) JOHNSTON, E. S. Evaporation compared with vapor pressure deficit and wind velocity. Monthly Weather Rev. **47**: 30–33. *3 fig.* 1919.

(10) JONES, L. R. Soil temperatures as a factor in phytopathology. Plant World **20**: 229–237. *2 fig.* 1917. Literature cited, p. 236–237.

(11) ————. Experimental work on the relation of soil temperature to disease in plants. Trans. Wisconsin Acad. Sci. **20**: 433–459. *4 fig., pl. XXXIII-XXXVII.* 1921.

(12) LIVINGSTON, B. E. The vapor tension deficit as an index of the moisture condition of the air. Johns Hopkins Univ. Circ. **293**: 170–175. 1917.

(13) ———— AND FORREST SHREVE. The distribution of vegetation in the United States, as related to climatic conditions. *xvi, 590 p., illus.* Washington, D. C. 1921. (Carnegie Inst. Wash. Publ. 284).

(14) MORSE, W. J. AND M. SHAPOVALOV. The Rhizoctonia disease of potatoes. Maine Agric. Exp. Sta. Bull. 230: 193–216. *Fig. 61–73.* 1914. Literature cited, p. 216.

(15) PELTIER, G. L. Parasitic Rhizoctonias in America. Illinios Agric. Exp. Sta. Bull. 189: 283–390, *23 fig.* 1916. Bibliography, p. 386–390.

(16) RICHARDS, B. L. Pathogenicity of Corticium vagum on the potato as affected by soil temperature. Jour. Agric. Res. **21**: 459–482. *5 fig., pl. 88–93.* 1921. Literature cited, p. 481–482.

(17) ROLFS, F. M. Potato failures. A preliminary report. Colorado Agric. Exp. Sta. Bull. 70: *20 p., 12 pl.* 1902.

(18) ————. Potato failures. A second report. Colorado Agric. Exp. Sta. Bull. 91. *33 p., 5 pl.* in text. 1904.

(19) TISDALE, W. H. Relation of soil temperature to infection of flax by Fusarium lini. Phytopath. **6**: 412–413. 1916.

(20) ———— Relation of temperature to the growth and infecting power of Fusarium lini. Phytopath. **7**: 356–360. *1 fig., pl. XI.* 1917.

PHYTOPATHOLOGICAL NOTES

Blister rust of the white pine. The question as to whether *Cronartium ribicola* would winter over on the currant has been before American plant pathologists almost ever since the white pine blister rust became an important factor on America. Thus far no satisfactory experiments have been carried out which would give a positive answer to this question. In 1921 a planting of black currants near Blue Anchor (Camden county) N. J. was selected for field test on this problem. This planting has been known to be infected for several years and although the surrounding country has been thoroughly worked by both Federal and State scouts the nearest known alternate hosts were fully three quarters of a mile distant and were not infected. In fact so far as known there are no infected pines in South Jersey. The planting is an inter-row crop in a young apple orchard which is just coming into bearing and is bounded on two opposite sides by narrow strips of forest. There is considerable forest in the immediate vicinity but no large areas.

This planting was examined in the late summer of 1921 by Dr. Perley Spaulding of the U. S. Bureau of Plant Industry and the writer, and found to be heavily infected with *C. ribicola* and it was definately decided to make a field test in 1922. Therefore, in March 1922 a double thickness cheese cloth tent was erected over a considerable number of plants by County Farm Demonstrator S. F. Foster and the writer. The cloth was furnished by the U. S. Bureau of Plant Industry. The tent was stretched over a ridge pole and securely anchored to the ground. During the summer of 1922 the entire planting was inspected by Dr. Haven Metcalf of the U. S. Bureau of Plant Industry and the writer in May, by Dr. H. H. York and the writer in June and by the writer alone in August. At the time of the first inspection a single infected leaf was found at considerable distance from the tent. At the time of the second inspection a considerable amount of infection was found in the planting. At the time of the third inspection the plants under the tent were found to be very generally infected but the infection was very light, i. e. there was rarely more than one or two spots on any one leaf. Infected plants were found throughout the planting but the infection was very light as compared with 1921. The writer realizes that the evidence is not conclusive, that it is possible that spores may have sifted through the cheese cloth tent but the evidence indicates that the fungus may possibly be carried from year to year on the currants.—MEL T. COOK.

Dwarf asparagus. At the Toronto meeting of the American Phytopathological Society, the writer reported a disease of asparagus which was of occassional occurrence throughout the state of New Jersey. From time to time for several years, dwarfed or stunted asparagus has been sent in for examination during the cutting season. These specimens were short, usually thick and slightly irregular in shape. They usually showed a slight cracking on the part of the stem below the surface of the ground and a discoloration varying from a slight brown to a pronounced rust. The most marked character was the dwarfing and it was this point that brought out the inquiries. In all cases, more or less Fusarium was found on the specimens. The complaints were so few that no efforts were made to study this trouble until the summer of 1921 when the writer's attention was called to two cases where the plants over circular areas in the fields were dwarfed and apparently dying. The disease was most severe in the centers of the areas, gradually becoming less prominent towards the margins which were not sharply defined. The areas had very much the appearance of having been struck by lightning but this idea was abandoned, (1) because the plants in the areas were never equal at any time to the surroundings plants although the variations were least noticeable very early in the season, (2) because there was no wilting, (3) because no other plants were injured, (4) because the trouble occurred over this same area from year to year. In these cases the diseased plants showed a pronounced brown or rusty discoloration on the stems below the surface of the ground, which resembled the browning on potato stems when infected with Rhizoctonia. The plants were dwarfed and died very slowly but new shoots were sent up and usually became infected. These plants were found to be heavily infected with Fusarium sp. During the winter of 1921–22 a number of healthy plants were grown in the green house and were inoculated with the organism from time to time. The results of these studies are as follows: (1) the organism is a pathogen producing the symptoms described above, (2) the younger the shoot the more easily it is infected, (3) when the stem gets above the ground without infection it is not likely to become infected, (4) infection is most easily accomplished if the stems are slightly injured, (5) very young stems may be infected without previous injury, (6) stems four inches or more in height are not likely to become infected, even though injured. Checks were used with every inoculation and the organism was recovered from the diseased plants.—MEL T. COOK.

A disease of dahlias. During the month of September 1922 Dr. M. A. Howe of the New York Botanical Garden called the attention of the writer to a mild disease of dahlias. This disease occurred on only two varieties, Snowdrift and Shasta, both of which are white. The first evidence of the disease is a water-soaked appearance of the stems accompanied by a wilting of the infected parts. The diseased parts die and become black and dry. The central cavities of the stems are more or less completely filled with a luxuriant growth of mycelium and a considerable number of large sclerotia developed. The sclerotia are somewhat larger and more abundant in Snowdrift than in Shasta and this holds true in the cultures from them. This organism has been determined by Professor H. H. Whetzel as *Sclerotinia libertiana*. The disease is not severe and cannot be considered of major importance. The writer is unable to say at this time whether this is a weak strain of the fungus or whether the plants are resistant. No experiments have been tried.—MEL T. COOK.

White pine blister rust in Michigan. Four different pine infections were located in Michigan during the past season. Three of these were found in Oakland County in the vicinity of Birmingham, and Royal Oak. These outbreaks clearly demonstrate the persistance of the rust in localities where it has previously appeared. In the vicinity of Birmingham, local currants and gooseberries were infected. The center of the infection was discovered early in the season and the diseased plants destroyed. *Ribes aureum* Pursh., *Ribes americanum* Mill., *Ribes cynosbati* L., *Ribes nigrum* L., and cultivated red and white currants (*Ribes vulgare* Lam.) were infected. *Ribes americanum* led the list in the number of diseased bushes. This was probably due to its abundance and favorable location with respect to the diseased pine. The dry 1922 season in this section of the state is also believed to have materially reduced the number of infections. The fourth pine infection was discovered about seven miles east of Grand Rapids in Kent County. This tree was found in a planting made from stock received from Ussy, France, in 1908 before the establishment of quarantine restrictions. This is the first time the rust has been found outside of Oakland County, and is the first known occurrence of the disease in western Michigan.

Scouting was supplemented by an educational campaign among the school children. A great deal of material was sent in for examination from all sections of the state, especially from the northern counties. Although no blister rust infections were located, the campaign aroused much interest in the protection of white pine.

The first blister rust infection on pine in Michigan was found in a nursery near Pontiac, Oakland County during 1917, a year later than the first reported outbreak of the disease in Wisconsin. Two infected pines were located the following year, one in a nursery near Birmingham and the other in a local ornamental planting. Scouting and inspection work were continued in 1919, but confined principally to white pine plantings and to currants and gooseberries in the vicinity of such plantings. Although the blister rust was not found in the same places where first discovered, another diseased pine purchased from a nursery near Birmingham was located in Oakland County. However, as in previous years all efforts to locate the disease on currants and gooseberries failed. No blister rust was found in the state during the scouting seasons of 1920 and 1921.

Small scattered stands of second growth white pine are frequently encountered in the northern half of the lower peninsula. Oakland County marks about the southern limit of native white pine in the eastern part of the state. In this county where it occurs very sparingly around some of the lakes there are numerous plantations of white pine. However, cultivated black currants are more or less prevalent and a constant source of danger to the pine because of their extreme susceptibility to the blister rust. As this disease is present in Wisconsin and the Province of Ontario, Canada, it was to be expected that the disease would sooner or later invade Michigan. Up to date, however, all infections can be traced to white pine of French origin.

Second growth pine as well as some virgin pine mixed with hardwoods is found in the upper peninsula. Wild and cultivated currants in this region favor the spread of the disease once it becomes established in that part of the state. The pine barrens or plains are somewhat isolated from the sources of infection already known. Wild currants and gooseberries are abundant along the streams and in the swamps, but do not occur on the sand. The state park at Interlochen, as well as many of the state forests are situated on the plains where the localized occurrence of currants and gooseberries will facilitate the control of the rust in these areas.—D. V. BAXTER.

International conference of phytopathologists in Holland, June 25 to 30, 1923. Attention was called to this important meeting in the March number of Phytopathology on pages 147–148. More details have been received and the following program is now announced.

Monday, June 25: Presidential address of welcome and lecture on plant diseases as seen from the standpoint of general pathology. Demonstration of experiments, especially on potato diseases. In the afternoon and evening addresses, papers and discussions of foreign and Dutch colleagues.

Tuesday, June 26: Address by Mr. van Poeteren on organization and methods of the Dutch Phytopathological Service. Discussion about international laws and requirements. In the afternoon, demonstrations of some methods of control of pests and diseases as practiced in Holland, e. g. the furrowing-wheel to destroy leather-jackets, control of American gooseberry mildew, of smut and stripe in grain crops, etc. Evening meeting: addresses, papers and discussions.

Wednesday, June 27, and Thursday, June 28: Trips through the country. To prevent congestion of the program, participants are requested to subdivide,—into those interested in agriculture, and those interested in horticulture. On Wednesday morning the first group will travel by rail to Friesland, where farms and selection fields of potatoes are to be visited; next day at Gröningen Agricultural Experiment Station, address of Mr. Hudig on diseases of crops on alkaline and sour soils, and visit to Mr. Hudig's experiments. Visit to the Experimental Farm of the Gröningen Seed Growers' Association or another farm of the same kind.

The second group will visit: first the nurseries of Boskoop and Aalsmeer, situated in a typical Dutch country region below sea level; thereafter visit to the bulb-growing districts near Haarlem. Dr. v. Slogteren will address the company and give a demonstration of modern methods of combating some bulb diceases, e. g. eelworm. This trip will wind up with a visit to the early potato districts of North Holland, where selection is practiced.

It would be possible, if desired, to form a third group for visiting other centers of culture, such as the Westland, the most important district growing vegetables and fruit under glass (grapes and peaches) of Holland (where results obtained by a winter spray with carbolineum against peach and grape scale will show at best advantage); afterwards the orchards in North Holland and the early potato selection fields in the same district might be visited.

Friday, June 29: Meeting of Baarn; address of Prof. Westerdijk on the cultivation of parasitic fungi and demonstration of research work. Afternoon devoted to discussions and inspection of the international collection of fungi cultures. This meeting will be prolonged during the evening for addresses, papers and discussions, and even to Saturday morning, if desired.

Saturday, June 30: In the afternoon the conference will leave for the Hague, for an informal meeting at the Office of the Minister of Agriculture (reception by or on the part of the Minister). Thereafter the committee will be pleased to entertain all participants at dinner in the bathing resort Scheveningen.

The Committee in charge of the Conference is composed of—Dr. H. M. Quanjer, Prof. Johanna Westerdijk, N. van Poeteren, T. A. C. Schoevers, J. Hudig, Dr. E. van Slogteren, G. Kruseman, J. C. Dorst, J. G. Hazeloop, E. H. Krelage, and J. H. van Straaten van Nes.

Opportunity will be given for the reading of papers or for the discussion of important questions on the subject of plant diseases or insect pests, and persons desiring to present papers or to have discussion on any such subject should submit abstracts, in advance of the meeting, to the Secretary, Mr. T. A. C. Schoevers, Villapark 8, Wageningen. Mr. Schoevers should also be notified in the case of each one planning to attend the conference, in order that proper arrangements for transportation and entertainment may be made. It is hoped that as many pathologists as can will endeavor to be in Holland during the latter part of June.—R. J. HASKELL.

Polyporus spraguei Berk., cause of heart rot: *Polyporus spraguei* causes a brown friable rot in the heartwood of the trunk and roots of living *Quercus rubra, Q. prinus, Q. coccinea, Q. velutina, Q. marylandica* and *Castanea dentata*. In a mill yard near Salem, Indiana, 16 logs recently cut from living chestnut trees were infected with this fungus. Sporophores developed from the decay in the ends of the logs in about two weeks after the logs were cut. Dr. G. G. Hedgcock, and Mr. G. F. Gravatt both report finding the fungus growing from the heartwood of living oaks. The dark brown friable decay in advanced stages is uniform in the heartwood and is confined to the roots and the lower six to nine feet in the trunk. The fungus fruits abundantly from stumps after trees are cut and may so continue as long as there is any sound heartwood.—JAMES R. WEIR.

Leaf spot of lettuce. Apparently an undescribed Cercospora leaf spot of lettuce (*Lactuca sativa*) has been found at the College of Agriculture, Los Baños, P. I. It was first noticed about the middle of March, 1922 and disappeared the last of May when the plants died of old age.

The lesions at first appear as small watery spots at the edge of the leaf. Gradually the spots spread inward and the older diseased tissues turn brownish. The fruiting structures, consisting of conidiophores and conidia, are found on this dead tissue. The conidiophores measure from 63.2 to 130.3 μ long 6.3 to 7.5 μ wide with 5 to 8 septations; the conidia measure 43.4 to 96.3 μ in length, 4.7 to 5.6 μ wide with 5 to 12 septations. The brownish conidiophores are produced in bunches, are simple and erect, and are frequently geniculate as is common in this genus. The conidia are straight or slightly curved, hyaline, tapering from a rather wide base to a point, distinctly linear.

The disease is not fatal to the plant but at times every leaf is spotted and in many cases killed. I have searched through all available literature and I fail to find reference to such a Cercospora disease on lettuce. Therefore I suggest the name *Cercospora lactucae* n. sp. to designate the fungus. I am giving this name purely for convenience and I realize its use will be but temporary in that various Cercospora diseases have been found to be caused by the same organism on many different hosts. —COLIN G. WELLES.

Personals: Doctor O. A. Reinking has resigned from the University of the Philippines to take a position as plant pathologist in Honduras, for the United Fruit Company. Doctor Reinking recently received his doctorate at the University of Wisconsin where he has continued researches begun in the Philippines on coconut bud-rot. He obtained leave from the University of the Philippines about a year ago and returned to this country by way of British North Borneo, Java, Italy, Germany, France, and England, visiting important mycological and pathological institutions.

ABSTRACTS OF PAPERS PRESENTED AT THE FOURTH ANNUAL MEETING OF THE CANADIAN DIVISION, AMERICAN PHYTOPATHOLOGICAL SOCIETY, STE. ANNE DE BELLEVUE, PROVINCE OF QUEBEC, DECEMBER 7 TO 8, 1922.

La campagne contre les sauterelles dans Quebec in 1922. G. MAHEUX.

Plant diseases of 1922 in western Quebec. B. T. DICKSON.

Fifty diseases are mentioned among which the following are of interest as being new or of augmented importance during the season. Pink root of onion (*F. malli*) was noted for the first time from Quebec, the wilting leaves being later attacked by Botrytis sp. Celery Blight (*S. petroselini apii*) was serious. Powdery mildew of clover (*E. polygoni*) was of such widespread occurrence that clover fields appeared as if powdered with flour. Notwithstanding this, it was difficult to find the perfect stage. Sunflower stem-rot and wilt (*S. libertiana*) was common and rust (*P. helianthi*) was present to the extent of 75 per cent in Sept. *Phyllosticta* leaf spot on McIntosh apple gave 100 per cent infection in one orchard and Bitter rot (*G. rufomaculans*) on Fameuse was found in two orchards. Exceedingly heavy infestation with *E. pruni* causing bladder-plums occurred on wild varieties. *Septoria paeoniae* var. *berolinensis* was pronounced on Peony causing leaf, petal and stem spot.

The natural control of the green apple bug (Lygus communis var. novascotiensis Knight) by a new species of Empusa. A. G. DUSTAN.

The green apple bug is one of the most destructive pests in the apple-growing sections of Nova Scotia. In certain localities the insect has been mysteriously dying out and a study of its natural enemies shows that this is due to a new species of Empusa. The life history and morphology of this fungus have been worked out in detail. Studies concerning the economic importance have shown that the fungus lends itself readily to artificial dissemination.

Control of the onion maggot in 1922. W. J. TAWSE.

The Dominion Entomological Service. A. GIBSON.

Disinfection et parcelles. O. CARON.

The pollination of certain vegetable plants by insects. R. C. TREHERNE.

Wood v. fungi (Demonstration slides). R. J. BLAIR AND J. D. HALE.

Address by Dominion Fruit Commissioner. G. E. MCINTOSH.

The past and future of plant pathology. DR. MELVILLE T. COOK.

(Printed in full in Journal of Quebec Society for the Protection of Plants.)

Report of the Plant Disease Survey. F. L. DRAYTON.

Cultural reactions of some dry root-rot organism. T. G. MAJOR.

Seven species of Fusaria were grown on seventeen different media at different temperatures and at different H-ion concentrations to determine the effects on growth characteristics. There is a variation in type of growth, colour production, chlamydospore production, and type and size of the macroconidia on the different media. More luxuriant mycelial growth with more intense colouration occurs at 25° C. than at 20° C. but spore size is practically unaffected. A gradation in growth characters was apparent in some species but the reaction of the medium is not the only factor concerned.

The present status of white pine blister rust in Canada. A. W. MCCALLUM

Blister rust is now present in the following provinces—Prince Edward Island, Nova Scotia, New Brunswick, Quebec, Ontario and British Columbia. In eastern Canada while the currant stage of the rust is fairly widely distributed the percentage of infected pines is surprisingly small. In British Columbia rust was first found in the autumn of 1921. This year work done in that province has shown that the disease is generally present in the coastal area and that any attempt at eradication or suppression would be quite hopeless. Rust has been present for at least twelve years in this section of the province. Late in the season rust was found on both pines and currants in the interior at Revelstoke and vicinity. The oldest infection found there was about five years of age. If further word does not show that rust is more widely distributed in this area it may then be possible to adopt methods of suppression.

Red branch of Conifers. J. H. FAULL.

Two diseases new to Ontario. J. E. HOWITT.

Two new diseases were found this summer, namely pink root of onions and white rot of grapes.

Pink root is established in the onion growing marshes southeast of Leamington. At least fifty acres of onions were affected by this disease this year. Many fields contained large patches of diseased plants and the growers estimated their loss at not less than 10 per cent of the crop.

White rot of grapes was found in vineyards near Winona and St. Catherines. This disease may cause very serious damage to certain commercial varieties of grapes. The variety which appeared to be most susceptible was Agawam or Rogers No. 15. Unsprayed rows of this variety had over eighty per cent of the bunches affected and unfit for market. White rot is easily confused with black rot. It can be told however, from the black rot by the fact that it apparently always shows on the pedicels first followed by a wilting of the berries which later develops brown lesions, shrivel up and become covered with light brown pycnidia. One year's experiments indicate that white rot even on very susceptible varieties is readily prevented by spraying with Bordeaux mixture as recommended for black rot.

Control of oat smut. DICKSON, B. T., R. SUMMERBY AND J. G. COULSON.

Co-operative experiments (with the Plant Protection Institute) were carried on during 1922 to test the efficacy of copper carbonate dust and other treatments. Banner and Hulless 709 M. C. were used. Formaldehyde spray adversely affected germination in Hulles 709 M. C. Field counts showed 1½ per cent smut in check Banner as against 0 per cent in plots treated with copper carbonate dust and an average of 49 per cent

smut in check Hulless 709 M. C. against 0.3 per cent in plots treated with copper carbonate dust. The latter treatment was almost as efficient ad the formaldehyde spray and less injurious to germination.

Abstract of five-years co-operative experiments in the prevention of oat smut. J. E. HOWITT AND R. E. STONE.

Experiments were conducted to show the effectiveness of the dry formaldehyde treatment for the prevention of oat smut. Forty three trials were made and 3,002 bushels of oats treated. The average results of the five-years experiments: Average amount of smut in crop from treated seed .6 per cent. Average amount of smut in crop from untreated seed 3.7 per cent. Average germination of treated and untreated seed was found to be exactly the same, namely 97.5 per cent.

Tests of copper sulphate dip, formalin sprinkle, formalin spray and the so-called dry formaldehyde treatment for oat smut, copper carbonate dust, 2 ounces per bushel and dehydrated copper sulphate and lime, 2 ounces per bushel. Results: copper carbonate dust and copper sulphate dust did not prove satisfactory in the control of oat smut this year on hulled varieties of oats. Copper carbonate dust gave good control of oat smut with the Liberty hulless oats, without any appreciable injury to the germinative capacity of the treated seed. The so-called dry formaldehyde treatment proved to be one hundred per cent efficient this year under plot conditions.

The control of raspberry mosaic. J. F. HOCKEY.

The results of rogueing experiments on the control of mosaic in commercial plantations have proven sufficiently successful to warrant publicity. Plantations which had in 1921, 4.71 per cent, 11.7 per cent and 31.17 per cent were rogued once and in 1922 there was present in these patches, respectively 0.33 per cent, 1.25 per cent and 2.27 per cent. Several of the mosaic plants found this year were new infections which had not shown symptoms at the time of rogueing, others were stray canes from plants which had been rogued. It is evident that by thorough rogueing of one and two year old plantations the disease can be profitable controlled. Rogueing of fruiting plantations over three years is not generally advisable.

Balsam rusts. H. P. BELL AND J. H. FAULL.

Peony diseases. J. G. COULSON.

A study of the diseases of the peony carried on at MacDonald College, P. Q. has shown it to be subject to the following seven diseases.

1. Botrytis blight (*Botrytis paeoniae* Oud.) most troublesome on the buds causing also a small amount of leaf and stem blight.

2. Cladosporium leaf blotch (*Cladosporium paeoniae* Pass.) estimated infection on all varieties 5 per cent.

3. Septoria leaf spot (*Septoria paeoniae* West var. *berolinensis* Allesch.) a very troublesome disease on leaves and stems. The infection for the falls of 1921 and 1922 ranged from 0 to 85 per cent on different varieties. The average for all varieties was estimated at 20 per cent. This is the first time this fungus has been reported in Canada.

4. "Mosaic" diseases—found on a few varieties but not serious.

5. Two leaf spots of unknown cause.

(a) Characterized by small irregular lead white spots with a comparatively broad purple border. Spots confined mostly to upper surfaces of leaves—Estimated infection —2 per cent. Believed to be due to an undetermined Phyllosticta.

(b) Definitely limited irregular yellow spots, 2–8 mm. broad with a dark border. Estimated infection 2 per cent. An Alternaria is believed to be the cause.

6. Disease of the underground parts.

One plot of peonies was very heavily infected with a typical root rot with a blackening of the rhizome and base of stem. A Fusarium was constantly associated.

Root rot and blight of canning peas. R. E. STONE.

During the summer of 1922 our attention was directed to a serious root rot and blight of canning peas. The disease is particularly prominent in Prince Edward county and the farms engaged in growing canning peas for seed. In many cases only spots in the fields are affected but on some farms whole fields show the presence of the disease and did not produce as much seed as was sown.

Enough experimental work was carried on to show that seed treatment and the use of fertilizers in commercial quantities would be of no bene;fit.

One of the fungi isolated from the diseased plants was Fusarium sp., but it is probable that other fungi may be associated with the trouble.

At present the plans suggested for combatting the spread of the disease include; 1. A long period of rotation. 2. Thorough drainage, 3. Use of resistant strains of peas.

Distribution of Ribes and Cronartium ribicola in Ontario. G. H. DUFF.

Bacterial soft rot of Iris. J. K. RICHARDSON.

The disease is a typical soft rot, destroying the rhizome as well as the foliage. Thirty-six rot-producing organisms were isolated from various sources and inoculations carried out, which resulted in obtaining typically diseased plants from the inoculations with two of the isolated organisms. These two reacted in a similar manner to, and appear to be, forms of *Bacillus carotovorus* Jones.

Blue stem of the black raspberry. J. F. HOCKEY.

The blue stem disease of black raspberry as originally described by Lawrence (Wash. Agr. Experiment Station Bulletin 108, 1912) has been found in commercial plantations scattered through the Niagara district. A fungus growth of the Verticillium type and corresponding to the description of Aerostalagmus caulophagus, Lawrence, was readily isolated in culture and is now under observation and study. It appears from Carpenter's article in the Journal of Agricultural Research **12**: 529–546, as though this organism differs very little from and probably is identical with *Verticillium albo-atrum*, Reinke and Berthold.

Plant pathology in public schools. W. A. MCCUBBIN.

Dusting with copper carbonate and other substances for smut control. W. P. FRASER AND P. M. SIMMONDS.

Experiments were carried out in co-operation with the Dominion Experimental Farms at Indian Head, Rosthern and Scott in Saskatchewan and at Lacombe in Alberta. Copper carbonate dust, copper sulphate and lime and a number of other substances were used and compared with the wet formaldehyde treatment. In all cases the formaldehyde solution gave perfect control. Copper carbonate dust was fairly effective in the wheat experiments, reducing the bunt present to about ½ per cent. With Banner oats the smut was reduced by copper carbonate to about one per cent. In the experiments with Liberty oats (hulless) which are seriously injured by formaldehyde treatment, copper carbonate dust reduced to smut to a small percentage except where the

check plots showed a very high percentage of smut. Copper sulphate and lime and the other substances used for dusting were not satisfactory.

Treatment of wounds in tree surgery. R. E. COSSETTE.

The bronze birch borer. C. B. HUTCHINGS.

Preservative treatment of farm timbers. J. H. CODERRE.

A contribution to the knowledge of the tree destroying fungi of the Vancouver forestry district. N. L. CUTLER.

A study was made of tree destroying fungi in the region of Vancouver. The following 24 species were found to be important:

Fuscoporia ferruginosa (Schrad.) Murr.

Fomitiporia tsugina Murr.

Poria sp., P. subacida Pers.

Fomitiporella betulina Murr.

Coriolus versicolor (L.) Quel., *C. delectans* Murr., *C. balsameus* (Peck) Murr., *C. abietinus* (Dicks.) Quel.

Piptoporus suberosus (L.) Murr.

Polyporus fissus Berk.

Lactiporus speciosus (Batt.) Murr.

Phaeolus sistotremoides (Alb. & Schw.) Murr.

Fomes roseus (Alb. & Schw.) Cooke, *F. ungulatus* (Schaeff.) Sacc., *F. laricis* (Jacq.) Murr.

Pyropolyporus robiniae Murr.

Porodaedalea pini (Thore) Murr.

Elfingia megaloma (Lev.) Murr.

Ganoderma oregonense Murr., *G. sessile* Murr.

Daedalea confragosa (Bolt.) Pers.

Gloeophyllum trabeum (Pers.) Murr., *G. abietinellum* Murr.

Twenty four species of fungi were found associated with timber rots in this district. Of these, six belong to the tribe Poriae, eight to the tribe Polyporae, eight to the tribe Fomiteae, three to the tribe Daedaleae, one to the tribe Ascomycetes.

The species were distributed on the various hosts as follows:

On *Pseudotsuga taxifolia*	7	species
Tsuga heterophylla	12	"
Tsuga mertensiana	1	"
Picea sitchensis	2	"
Acer sp.	1	"
Acer macrophyllum	1	"
Alnus rubra	2	"
Rhamnus purshiana	1	"
Host unknown	3	"

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